AUSTRALIAN SPECIES OF THE FUNGAL GENUS CORDYCEPS (Fr.) Link

(with critical notes on collections in Australian herbaria)

by

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SUMMARY

This paper embraces: a short history of the discovery of *Cordyceps* species in Australia; an artificial key to the 15 taxa (known to occur in the Commonwealth and believed to be specifically distinct); the synonymy for each species, list of collections represented in Australian herbaria, location of types, names of host-insects (where known) and sundry comments on identities and nomenclature; a bilbliography concerning Australian collections of *Cordyceps*.

INTRODUCTION

Specimens of *Cordyceps* are no less intriguing to the modern botanist than when, two centuries ago, they were regarded as a *lusus naturæ*—the transmutation from animal to plant kingdom. The permanency, with which " mummified " bodies of the host-insect retain their outward form, heightens the interest of these parasitic fungi. Another remarkable fact is that certain species may occur either in the perithecial (perfect) phase or in one or more quite dissimilar conidial states. Some kinds of entomogenous fungi produce only conidial fruiting bodies; these are classified under such form-genera as *Isaria*, *Hirsutella*, *Hymenostilbe*, *Sporotrichum*, *Stilbum*, &c., although their relationship (and perhaps identity) with undoubted members of *Cordyceps* is suspected.

The only comprehensive world revision of this genus since the 19th century is by Y. Kobayasi (1941) who recognized 137 species. Japan (34 spp.), North America (31), Brazil (31), Belgian Congo (24) and Java (17) appear to be the richest centres of development. Australia (including Tasmania) is credited with only ten species, according to Kobayasi; but these include *C. taylori* (Berk.) Sacc. which is most probably the largest " vegetable caterpillar " fungus in the world, its branched sporophores often attaining heights up to 1 foot. Kobayasi notes (1941, p. 216) that almost half the total species of *Cordyceps* are known solely by the original collection, which would suggest that most species are of quite rare occurrence; however, the lack of systematic collecting doubtless accounts for an astonishing paucity

of herbarium specimens—at least in Australia. One or more species is known to occur in each of the Australian States except Western Australia, whence material of an isarioid growth on large cicada larvae (but apparently not *Isaria cicadæ* Miq.) reached me during 1953. The eventual discovery of several *Cordyceps* species in such a vast region as the Western State is only to be expected.

At least three different *Isariæ* have been recorded from insect larvae in eastern Australia, viz.: *I. surmatodes* McAlpine (Sept., 1895) on a cockchafer beetle at St. Kilda, Vic.; *I. cicadæ* Miq. [in *Bull. Sci. phys. et nat. Neerl. 1*: 85, t. 1, fig. A (1838), also *Ann. Sci. nat.* ser. 2, *10*: 378 (1838)—type from Bahia, Brazil] on a Victorian cicada specimen, but without definite locality, and *I. suffruticosa* Cooke & Massee (1889) on a hairy caterpillar in New England district, N.S.W. The two latter records were published by M. C. Cooke (Aug., 1892, p. 383), and H. T. Tisdall (1893, p. 94) discusses an unidentified *Isaria* found on a moth cocoon under a charred log at Nar-Nar-Goon, Vic.

It is now possible to extend the range of *I. cicadæ* to Queensland, where excellent fruiting material was collected on the ground in eucalypt forest at Mt. Nebo, Manorina National Park, by Mr. and Mrs. A. B. Cribb in February, 1956. The highly branched conidiophores all emerge from the head of the small host-cicadas (apparently *Melampsalta* sp.) and the flesh-pink to orange-reddish fertile heads (each about 2 mm. long) are aggregated like bunches of grapes. Under *I. cicadæ*, Petch (1933, p. 65) lists as a synonym *I. sinclairii* (Berk.) Lloyd, 1923, which is not uncommon in New Zealand, its type (at Kew) having come from Tauranga on Poverty Bay. Dingley (1953, p. 339) is not correct in writing " Petch stated that the perfect stage was *Cordyceps sobilifera* (Hill.) Sacc." Petch's actual words (1933, p. 64) were: " *Isaria sinclairii* is generally accepted as the conidial stage of *Cordyceps sobolifera*, though no evidence of that relationship has been adduced, except that both grow on *Cicada* nymphs ".

Type of *Cordyceps sobolifera* (Berk.) Berk. & Broome, 1875, came from the West Indies and is, presumably, in the cryptogamic section of the Natural History Museum at Paris. This species, with usually solitary clubs surrounded by sterile, conidiophore-like " soboles ", extends to Mexico, Japan, China, Ceylon and Madagascar; so it might well be represented in the Australian region.

H. Tryon (1893, p. 54) reported the occurrence of a hyphomycetous fungus—probably *Isaria* sp.—on a mummified scarabaeid beetle larva at Yandilla, Queensland, while the present writer has found white but barren isarioid growths (to 1 cm. high) all over the brown-woolly cocoon of a grass moth (*Anthela acuta* Walk.) at Beenak, Vic. (May, 1935). The latter may possibly represent *I. suffruticosa* Cooke & Massee, to which *I. japonica* Yasuda ex Lloyd, 1917, is very closely allied if not conspecific. Mrs. K. Healey has recently found excellent examples of the same parasite on woolly moth cocoons at Tarra Valley National Park, Vic. (June, 1959).

Cordyceps is known to parasitize a wide diversity of hosts, including larvæ of numerous genera of *Coleoptera* (beetles), *Hemiptera* (bugs and cicadas), *Orthoptera* (cockroaches and crickets), *Lepidoptera* (moths and butterflies), *Hymenoptera* (ants and wasps) and *Diptera* (flies). It is usual for fruiting bodies to emerge just behind the head of the host, but occasionally they appear between the anal or intermediate segments. Occurrences of *Cordyceps* on spiders are comparatively rare (e.g., the Japanese *C. arachneicola* Kobayasi, and tropical American *C. caloceroides* Berk. & Curt.), while a few boreal species—*C. japonica* Lloyd, *C. jezoensis* Imai, *C. ophioglossoides* (Fr.) Link, *C. intermedia* Imai and *C. capitata* (Fr.) Link—are restricted to underground fruiting bodies of the fungal genus *Elaphomyces*. Frequently each *Cordyceps* is peculiar to a single host or to several related species, yet the almost cosmopolitan *C. militaris* (Fr.) Link has been recorded for at least 13 genera of *Lepidoptera*, as well as on coleopterous pupae and the cocoons of certain *Hymenoptera*. Conversely, the large Victorian swift moth larva *Oxycanus diremptus* is known to be parasitized by at least four species of *Cordyceps*: *C. gunnii* (Berk.) Berk., *C. hawkesii* G. R. Gray, *C. cranstounii* Olliff and *C. robertsii* (Hook.) Berk. were all found on this grub within an area of a few square yards along Koonung Creek at Doncaster, Vic., by Mr. and Mrs. Paul Fisch in June, 1942, and more recently (June, 1959) the same four species were gathered on *Oxycanus* at Tarra Valley National Park, Vic., by Mrs. K. Healey (*vide* specimens in Melbourne Herbarium).

The writer has personally examined all *Cordyceps* exsiccatae housed in the National Herbaria at Melbourne and Sydney, the National Museums of Victoria and South Australia, the considerable material in the Botany Department of Melbourne University (amounting to 22 collections, including types of three species) and, by courtesy of Dr. N. T. Flentje (pathologist), eight of the twelve collections of *Cordyceps* in the Waite Agricultural Research Institute at Adelaide. He is also indebted to Dr. Winifred M. Curtis, Mr. R. C. Carolin and Mr. A. Musgrave (through Director J. W. Evans) for valuable information on the material housed in the respective herbaria of Hobart University, Botany Department at Sydney University and the Australian Museum (Sydney). There are no Australian specimens in the State Herbaria at Perth, Adelaide or Brisbane.

Special thanks are due to Dr. Alan B. Cribb (Botany Department, University of Queensland, Brisbane) who willingly placed at my disposal the four *Cordyceps* collections (1954–56) of his own fungal herbarium, and gave permission to publish any pertinent details. These collections (all by Cribb and his wife) comprise four distinct species—*C. gunnii*, *C. hawkesii*, *C. robertsii* and *Isaria cicadæ* Miq.—none of which have been recorded previously for Queensland; indeed, the genus *Cordyceps* would seem to have been hitherto quite unknown in that State. All three species came from rain forest along Coomera track in the Lamington National Park—presumably on the same large hepialid moth larva (as happened at Doncaster, Vic., in 1942). It is possible that some other important collections exist in private herbaria; but, if so, details have eluded me.

RECORDING OF SPECIES FOR AUSTRALIA

Apparently the first species to be discovered in the Australasian region was *C. robertsii*, diagnosed as a *Sphaeria* by W. J. Hooker (1836) from New Zealand material, but later recorded for Tasmania (Rodway, 1920), found in Victoria (1942), in New South Wales (1947)* and Queensland (1955). Kobayasi (1941, p. 102) extends its range to Chile. The host in each instance is a large lepidopterous larva in the Swift Moth family, *Hepialidæ* (e.g., *Oxycanus diremptus* and probably *O. fusco-maculatus*).

A second Australasian species was collected on the banks of Murrumbidgee River near Yass, N.S.W., in 1837; it was first described and figured as *Sphaeria innominata* by Rev. R. Taylor (1842), but has been universally known under the name *Cordyceps taylori* for the past century—the inadmissibility of the latter, and probably both epithets, will be discussed elsewhere. In 1896 *C. taylori* was rediscovered at Queanbeyan, less than 40 miles south-east from the type locality; in the meantime, however, no less than six independent collections had been made in the Otway Ranges, Vic. (1886–94), two between the Ovens and Mitta Mitta Rivers, two in the Strzelecki Ranges of South Gippsland and one labelled "Caulfield" (1870). This large and remarkable ascomycete is still known only from Victoria and south-eastern New South Wales.

The third Australian taxon to receive recognition was *C. gunnii*, described under the genus *Sphaeria* by Rev. M. J. Berkeley (1848) on the basis of a Tasmanian collection from Launceston district—not "Lancaster" as in the original description. This is the most widely distributed and by far the best known Australian species, occurring in all States except Western Australia and extending also to the North Island of New Zealand. Its large, usually simple, dark olive-green heads appear early in winter, mostly under *Acacia* trees (e.g., the Silver Wattle, *A. dealbata*), and fruiting bodies are well represented in herbaria. The first Victorian specimen would seem to be one taken at Studley Park, Melbourne, in 1857 by W. Kershaw and now in the possession of his great-grandson (R. C. Kershaw of West Tamar, Tas.); strangely enough, F. Mueller does not seem to have noticed the species before 1874, when it appears in his *Report* as Government Botanist (p. 12). Subsequent collections have been made almost throughout the cooler parts of the State—from Portland to Mallacoota.

C. gunnii was collected in New South Wales at least as early as 1888 (Shoalhaven River), on the Hunter River, then at several parts of the Blue Mountains, and later still in the National Park (south of Sydney) and in the Riverina district. Tepper and McAlpine (1897) recorded the species for South Australia on the basis of several collections from Kingston and Sellick's Hill. By courtesy of the Director, South Australian Museum, the present writer has been able to examine three of these collections and he agrees with McAlpine's identifications of 1897. Almost half a century later (in 1942 and 1943) *C. gunnii* was collected at Kingston again and

* Several collections from the Port Jackson area were recorded under the name of *Cordyceps selkirkii* by Olliff (1895).

the record published, together with a coloured illustration, by J. R. Harris (1946). No other species of the genus is known to occur in South Australia. The first, and only, Queensland collection would seem to be that of A. B. and J. W. Cribb—from Lamington National Park in the far south-east, May 1955.

C. hawkesii was described (as a *Sphæria*) from Tasmania by G. R. Gray (1858). The type, presumably at British Museum (Natural History), has not been consulted; but similar, or perhaps identical, material was collected on the Snowy River near Orbost, Vic. (1890)—subsequently at Doncaster, Cockatoo, Olinda, &c.—at Coonamble, N.S.W. (about 1894), and lastly in the Lamington National Park, Queensland (May, 1954).

F. Mueller and Berkeley (1878) published a description and figure of *C. meneristitis* (the epithet erroneously rendered "*menesteridis*"), their type coming from the mouth of Yarra River, Vic.; M. C. Cooke (Aug., 1892) reduced it to a variety of the European *C. entomorrhiza* Link, and Kobayasi (1941, p. 140) made it a doubtful synonym of his own new Japanese species, *C. gracilioides.*

The *Stilbum formicarum*, described by Cooke and Massee (1889) from an ant collected at Cheltenham, Vic., was considered by T. Petch (1933, p. 67) as referable to a conidial state of the Brazilian *C. bicephala* Berk.

Only three species of *Cordyceps* were accorded an Australian distribution by Saccardo (1883) and Cooke (Aug., 1892) in their respective fungus floras of the world and of Australia. *Saccardo omitted *C. hawkesii*—probably not having seen Gray's private and rather obscure pamphlet of 1858—and the latter authority, for some inexplicable reason, failed to mention *C. taylori*. D. McAlpine (1895) listed the four species known from Australia at that date (viz., *C. taylori*, *C. hawkesii*, *C. gunnii* and *C. entomorrhiza* var. "*menesteridis*"); he also admitted typical *C. entomorrhiza* for Victoria.

The next comprehensive account of Australian species appeared in June, 1895, by A. S. Olliff, Government Entomologist of New South Wales, who died six months later at the early age of 30. He provided illustrations and diagnoses for six species, believed to be new, making a total for the Commonwealth of ten. Although this attempt to name several apparently undescribed entities was praiseworthy enough, Olliff was not a botanist and his revision called forth adverse criticism. L. Rodway (1900) remarked:

> Mr. Olliff . . . drew attention to the forms found in Australia, at the same time describing many forms as new species. I doubt if mycologists will accept them all. *C. selkirkii* and *C. coxii* are too close to *C. larvarum* [=*C. robertsii*] and *C. trictenæ* owes its existence to an unfortunate oversight. . . .

And C. G. Lloyd's opinion (1920) concerning the same revisionist was expressed thus:

> From the systematic account of *Cordyceps*, however, Mr. Olliff seems to us to be very local in his view, and his species, we believe, should mostly be referred to others.

* Saccardo later listed *C. hawkesii* in *Sylloge Fungorum* 9 (*Supplementum Universale*): 1001 (1891).

One of Olliff's six "new" species (*C. selkirkii*) is almost certainly a form of *C. robertsii*, another (*C. pieli*) seems to be merely *C. hawkesii*, while a third (*C. trictenæ*) is actually based upon the type illustration of *C. taylori* (published as *Sphaeria taylori* Berk., 1843)! The remainder (*C. scottiana*, *C. coxii* and *C. cranstounii*) appear to be genuine novelties, worthy of specific rank, but their types have not been located and their circumscription must rest upon the original figures and rather inadequate descriptions. A possible type specimen of *C. coxii* is preserved in the Insect Gallery at the Australian Museum, Sydney; this has not been examined by the present writer.

C. scottiana is not known other than by the type collection (Hunter River, N.S.W., 1861) which may be among Berkeley's numerous fungi at Kew; the original specimens of both *C. coxii* and *C. cranstounii* came from Kurrajong Heights, N.S.W.; but collections conforming well to the descriptions of these entities have been made in Victoria during the past twenty years.

Also in 1895 G. Massee published another new species, *C. henleyæ*, the type coming from Ovens River, Vic., in 1893. E. Cheel, as reported by Lloyd (1920), made the suggestion that *C. henleyæ* was merely a branched condition of *C. robertsii*; it seems to connect this species with *C. taylori*, and, in my opinion, would be better placed as a form of the latter (with which it shares the same very large hepialid host-larva). In C. G. Lloyd's *Synopsis of the Cordyceps of Australasia* (1915), *C. henleyæ*, *C. taylori*, *C. gunnii*, *C. dovei* [see below] and *C. gracilis* are considered as "good" Australian species; to the last-named Algerian species Lloyd referred *C. meneristitis* F. Muell. & Berk.

During the present century five species have been added to the *Cordyceps* flora of the Commonwealth—four from Victoria and one from Tasmania: *C. dovei* Rodway (1900) was presented from Mt. Bischoff, western Tasmania, and later noted in the North and South Islands of New Zealand; *C. furcata* McLennan & Cookson (1923) and *C. brittlebankii* McLennan & Cookson (1926), both described from Ringwood, Vic.; *C. aphodii* Matthieson (1949) from Miner's Rest, near Ballarat, Vic.; and what appears to be a form of the boreal genotype, *C. militaris* Link, from chrysalids in the Otway Ranges, Vic. (first noted in Sept., 1935, and collected there again during the next two years). From time to time, there are found in Australia *Cordyceps* fruiting bodies which do not satisfactorily match the existing descriptions, and it is likely that a number of endemic species still awaits recognition—especially those on small or little-known insects.

Joan M. Dingley's monograph (1953) on the *Hypocreales* of New Zealand includes eight species of *Cordyceps* (three being new to science) and is the most recent treatment for a large region in the Southern Hemisphere. She assigns *Cordyceps*, and five other genera, to the family *Clavicipitaceæ*. The three species (*C. robertsii*, *C. gunnii* and *C. dovei*) common to Australia and New Zealand are described in detail. Probably one or more of the four species, at present considered endemic in that Dominion, may extend to Australia.

ARTIFICIAL KEY TO AUSTRALIAN *CORDYCEPS* SPECIES.

1. Perithecia entirely immersed in stroma——6
   Perithecia superficial or very prominently exserted——2
2. Fertile portion of sporophore *terminal, orange*, obtuse, unbranched, 2–20 mm. long (on chrysalids of various *Lepidoptera*)——**C. militaris**
   Fertile portion not terminal, never orange; apex of sporophore sterile, often slender (on larvæ)——3
3. Stroma 3–10 mm. long, 1–2 mm. wide, *pale ochraceous*; perithecia darker, forming irregular, often lateral pads 3–5 mm. long and occupying the greater part of fructification (on cerambycid, or longicorn, beetle grubs—several to many, rarely only 1–2, sporophores crowded around neck of host)——**C. dovei**
   Stroma > 30 mm. long (and up to 20 cm.), *bay brown*; perithecia *dark brown* to blackish——4
4. Stipe *glabrous*, very slender, simple or forked; perithecia *acute*, 0·2–0·3 mm. long (on scarabæid, or cockchafer, beetle larvæ)——**C. coxii**
   Stipe *brown-tomentose* toward base; perithecia *obtuse* (on large moth larvæ)–5
5. Fructification simple or slightly branched, *slender*, never > 3 mm. wide (usually 1–2 mm.) at junction with host; perithecia *truncate*, ± 4 per mm., 0·3–0·5 mm. long (host < 15 mm. thick)——**C. robertsii**
   Fructification usually much branched, antler-like and *massive* (or, if occasionally simple, then > 3 mm. wide at point of emergence from host); perithecia often ± apiculate, 5–6 per mm., 0·1–0·2 mm. long (host ± 20 mm. thick)——**C. taylori**
6. Stipe *hair-like*, ± 5 cm. long, simple or once-forked, smooth, dark brownish; capitula almost *globose*, 2–3 mm. long (on ants—the perithecial stage unknown in Australia, where small pink-headed conidiophores spring from various parts of host)——**C. bicephala**
   Stipe neither hair-like *nor* associated with ants——7
7. Fructification *very small* (< 3 cm. long) but relatively stout, often *multiple* or branched; capitulum < 5 mm. long——12
   Fructification > 3 cm. long, frequently single and simple; capitulum at least 5 mm. long (often more)——8
8. Capitulum dark reddish-brown, 5–10 mm. long, with paler and usually acute *sterile terminal beak* (4–8 mm.); stipe 1–2 mm. wide (on scarabæid beetle larvæ)——**C. brittlebankii**
   Capitulum fertile up to the obtuse, rounded apex——9
9. Stipe > 3 mm. wide (often up to 10 mm.), undivided, sometimes 20–30 cm. long; capitulum normally > 10 mm. long (on hepialid moth larvæ)——11
   Stipe < 3 mm. wide *or* irregularly much branched; capitulum to 10 mm. long——10
10. Mouths of perithecia *distinct and widely spaced* (4–7 per mm.); stipe very flexuose, irregularly *branched* (with several yellow capitula) and *lacerate* (on hepialid moth larvæ)——**C. cranstounii**
    Mouths of perithecia microscopic, > 7 per mm.; stipe *undivided, smooth*; capitulum *brick-reddish or sepia*, 5–8 mm. long (on tenebrionid beetle larvæ)——**C. meneristitis**
    As for the last, but the *yellow-brown* capitulum ± 10 mm. long and host a lucanid beetle larva——**C. scottiana**
11. Living capitulum dark *olive-green to blackish*, ill-defined below where it *merges gradually* into the pale yellow stipe, usually with small longitudinal wrinkles or creases and protruding perithecial mouths in the dried state——**C. gunnii**
    Living capitulum *bay* or *coffee-brown*, well-defined and *sharply distinct* from the paler brown stipe, not wrinkled in drying——**C. hawkesii**
12. Capitula 3 per stipe, each 4–5 mm. long, *red-brown, regularly ovoid*, sharply contracting into a nipple-like apical point (identity of larval host unknown)——**C. furcata**
    Capitulum *solitary*, 3–4 mm. long, *ochre-brown*, sometimes ± *distorted* (on scarabæid, or cockchafer, beetle larvæ)——13
13. Perithecia ± *scattered, obliquely inclined* toward axis——**C. aphodii**
    Perithecia close and *compact, perpendicular* to axis——**C. sp.**

ALPHABETICAL ARRANGEMENT OF SPECIES, SYNONYMY, HOSTS, LOCATION OF TYPES, AND COLLECTIONS IN AUSTRALIA

The following standard abbreviations have been used for various herbaria (the numbers in brackets indicating collections of Australian *Cordyceps* material housed in each local herbarium):

ADM (3)	South Australian Museum, Adelaide.
ADW (12)	Waite Agricultural Research Institute, Adelaide.
BDW	Botany Division, Department of Scientific and Industrial Research, Wellington, N.Z.
BM	British Museum (Natural History), London.
CANTY	Canterbury Museum, Christchurch, N.Z.
HO (10)	University of Tasmania (Botany Department), Hobart.
K	Royal Botanic Gardens (Herbarium), Kew, London.
LPS	Institute de Botanica C. Spegazzini, La Plata, Argentina.
MEL (40)	National Herbarium, Royal Botanic Gardens, Melbourne.
MELM (12)	National Museum of Victoria, Melbourne.
MELU (22)	University of Melbourne (Botany School).
NSW (9)	National Herbarium, Royal Botanic Gardens, Sydney.
PR	Botanical Department of National Museum, Prague, Czechoslovakia.
SYD (5)	University of Sydney (Botany Department).
SYDM (5)	Australian Museum, Sydney.
US	National Museum and Smithsonian Institute, Washington (including Lloyd Herbarium, now under loan to Plant Industry Station, Beltsville, Md.).

C. aphodii J. Mathieson in *Trans Brit. mycol. Soc.* **32**: 134, t. 12–14 (1949).

Host: Aphodius howitti Hope (*Coleoptera*—Scarabæidæ).

Type: Miner's Rest, near Ballarat, Vic. (*J. Mathieson,* Oct., 1946—MELU).

Other Collections: Miner's Rest, near Ballarat, Vic. (*J. Mathieson,* July, 1945—MELU, asexual stage).

The author of the species gives a very detailed account of all stages of the parasite, its artificial culture from both conidiospores and ascospores, secondary parasites which attack it and the life history of the host-insect (a small cockchafer beetle in the family *Scarabæidæ*). *C. aphodii* has not been reported beyond the type area in Victoria, but a very similar, still undetermined, species from New South Wales is discussed on page 85.

? **C. bicephala** Berk. in *Hook. J. Bot. Kew Gdn Misc.* **8**: 278 (1856).

C. australis (Speg.) Sacc. *Syll. fung. 2*: 571 (1883);

C. unilateralis Tul. supsp. *australis* Speg. in *An. Soc. cient. argent. 12*: 215 (1881)—TYPE (? LPS) on *Pachycondyla striata* from mossy trunks near Apiahy, southern Brazil (Dr. *Puiggari*);

Hymenostilbe melanopoda (Speg.) Petch in *Trans. Brit. mycol. Soc. 16*: 209 (1932);

Isaria melanopus Speg. *Bol. Acad. Cienc. Cordoba 11*: 620 (1889)—TYPE (? LPS) on decayed beetle from mossy trunks near Apiahy, Brazil (Dr. *Puiggari*);

Stilbum formicarum Cooke & Massee in *Grevillea 18*: 8 (1889)—TYPE (K) on an ant, "*Formica consobrina*", from sundew plant at Cheltenham, Vic. (*C. French,* ± 1888).

Host: Unknown (probably ant).

Type: Panure, near sources of Rio Negro, N.W. Brazil (*R. Spruce*, ± 1853 — K).

The synonymy given above reflects the opinion of T. Petch (1933, p. 67). It is generally conceded that the two taxa *C. bicephala* and *C. australis* (both described from Brazil) are conspecific, and it is practically certain that *Hymenostilbe melanopoda* (type of which came from the same tree-trunks as that of *C. australis*) is only a conidial stage of this species; but, since many distinct species of *Cordyceps* are known to parasitize ants, it is surely assuming too much to identify the single old Victorian collection of *Stilbum formicarum* with the perfect stage of a South American fungus? They may indeed be the same, but my doubt is expressed by the prefixing query to *C. bicephala* in this list of Australian *Cordyceps*.

E. B. Mains [*Bull. Torrey bot. Cl. 76*: 24–30 (1949)] supports Kobayasi (1941, p. 183) in taking up the name *C. australis* instead of the earlier *C. bicephala* Berk., because the latter was presumed to be based on a doubtfully mature specimen; but Berkeley's diagnosis explicitly mentions both asci *and* sporidia, and, in any case, the International Code of Nomenclature does *not* sanction rejection of any name on a plea of immaturity for the type on which it is based. Petch, in his belief that only a single species was involved, had every justification for synonymizing *C. australis* under *C. bicephala*. Kobayasi has extended the range of this fungus to Uganda in East Africa, and Mains (*l.c.*) presents it as a common parasite in the Western Province of Liberia, West Africa, " killing ants by thousands ".

C. brittlebankii E. McLennan & I. Cookson in *Proc. roy. Soc. Vict.* n. ser. **38**: 74, t. 5 fig. 5–6, t. 6 fig. 4–5 (1926).

Host: Heteronyx sp. (*Coleoptera*—Scarabæidæ).

Type: Ringwood, Vic. (*I. Cookson,* Apr. 1924—MELU).

Other Collections: Tyabb, Vic. (*J. M. Raff*—MELU).

The species has not been observed outside Victoria.

C. coxii Olliff in *Agric. Gaz. N.S.W.* **6**: 412, t. 4 fig. C–D (1895).

Host: ? *Lepidiota* sp. (*Coleoptera*—Scarabæidæ), also Cicadidæ (*Hemiptera*).

Type: In vicinity of turpentine trees at Kurrajong Heights, N.S.W. (*T. Cranstoun,* ? Mar., 1895 —— ? SYDM).

Other Collections: Concord, N.S.W. (*F. C. Lovegrove,* Aug., 1910—NSW); near Gembrook, Vic. (*J. H. Willis,* 1935—MEL); Between Daylesford and Trentham, Vic. (*Judith Thiele,* July, 1946—MEL); Alexandra, Vic. (*C. G. Lane,* Nov., 1907—MELM). [At the Entomological Branch of the N.S.W. Department of Agriculture, the writer has seen a collection of *Cordyceps*-bearing cockchafer larvæ from Taren Point on Botany Bay (*E. E. Mellenish,* Dec., 1934); the fruiting bodies on these are imperfect, without perithecia, but most probably referable to *C. coxii*.]

Although type of *C. coxii* has not been examined, the original figures and description (brief as it is) accord well with later collectings of a distinctive *Cordyceps* on cockchafer larvæ, which is here referred to that species.

Olliff (*l.c.*) suggests that *C. coxii* "may prove to be an extreme variety" of his species *C. selkirkii,* the latter always parasitizing large moth larvæ and differing in its longer, truncate, less crowded perithecia. The writer unhesitatingly supports Lloyd (1920, p. 912), Kobayasi (1941, p. 99) and Dingley (1953, p. 331) in relegating *C. selkirkii* to synonymy under *C. robertsii,* but he does not uphold Kobayasi's treatment of *C. coxii* as another straight synonym of "*C. larvarum*" [i.e., of *C. robertsii*].

C. cranstounii Olliff in *Agric. Gaz. N.S.W.* **6**: 408, t. 2 fig. B (1895). (Plate VIII).

Host: Oxycanus diremptus, and probably other species (*Lepidoptera*—Hepialidæ).

Type: Kurrajong Heights, N.S.W. (*T. Cranstoun*, Mar., 1895 ——? *loc.*).

Other Collections: Bola Creek, National Park, N.S.W. (*A. Burges,* July, 1947—MEL); Koonung Creek, Doncaster, Vic. (Mr. & Mrs. *Paul Fisch,* June, 1942—MEL, ADW No. 3142); without locality, Vic. (MELM); Tarra Valley Nat. Park, Vic. (Mrs. *K. Healey,* June, 1959—MEL).

The characteristic features of *C. cranstounii* are its *lacerate* (or irregularly byssaceous) stipe, multiple heads which are relatively short, obtuse, yellowish, with perithecial orifices large and *widely spaced.*

Type was not available for inspection, but the writer confidently refers the Bola Creek (N.S.W.) and Doncaster (Vic.) collections to this distinctive species.

Many fresh specimens from Doncaster were examined over a period of four months; but, although the fruiting heads of these had well-developed perithccia, in no instance could sporidia (or even differentiated asci) be found!

C. dovei L. Rodway in *Pap. roy. Soc. Tasm. 1898–1899*: 101, *cum icon.* (1900).

C. aemonæ Lloyd *Mycol. Notes* 66[2]: 932, fig. 1695 (1920)—TYPE (US) on *Aemona hirta* in rotting logs of *Melicytus ramiflorus,* Weraroa, New Zealand (*G. H. Cunningham,* No. 51, Sept., 1919); CO-TYPE (No. 78, ? BDW).

Host: (*Coleoptera*—Cerambycidæ).

Type: In decayed trunk of *Nothofagus cunninghamii* at Mt. Bischoff, Tas. (*H. Stuart-Dove*—HO; photo. of type MEL).

Although six collections have been recorded from New Zealand (widely distributed through both islands), the only one known from Australia is that of the type which came from the high-rainfall area of western Tasmania. In its comparatively very small fructifications (with sterile apices and half-exserted perithecia), more or less crowded near the head of the beetle-host, *C. dovei* is almost unique. New Zealand populations differ slightly from the Tasmanian in having longer, more slender, less crowded stromata (sometimes even single), with the fertile portions more distinctly lateral and sterile tips less truncated (sometimes acute). Lloyd recognized them as constituting a separate endemic species, *C. æmonæ,* but Kobayasi (1941, p. 103) reduced this to synonymy and pointed out the trifling nature of the differences.

C. furcata E. McLennan & I Cookson in *Proc. roy. Soc. Vict.* n. ser. **35**: 157, t. 10 (1923).

Host: Unknown larva.

Type: Ringwood, Vic. (E. McLennan & I. Cookson, Sept., 1922—MELU).

The species is known only by the single type collection.

C. gunnii (Berk.) Berk. in Hook. f. *Flor. Tasm.* **2**: 278 (1859).

(Plate IX, figs. 1–3).

Sphaeria gunnii Berk. in *Lond. J. Bot. 7*: 577, t. 22 (1848);

C. consumpta G. H. Cunn. in *Trans. N.Z. Inst. 53*: 377, t. 60 fig. 1 (1921)—TYPE (No. 230, CANTY) on buried larva of *Porina* sp. [= *Oxycanus* sp.] at Rotorua, N.Z. (*A. Lush*, June, 1920);

? *C. craigii* Lloyd *Mycol. Notes* 4^{39}: 527, fig. 718 (1915)—TYPE (US) on *Porina enysii* [= *Oxycanus enysii*] from old and abandoned kumara (*Ipomœa batatas*) beds at Auckland, N.Z. (*E. Craig*);

? *C. hillii* Lloyd *Mycol. Notes* 6^{65}: 1061, fig. 1994 (1921)—TYPE (US) from N.Z., without details (*H. H. Hill*).

Host: Oxycanus spp. (*Lepidoptera*—Hepialidæ).

Type: Franklin Village, near Launceston, Tas. (*R. C. Gunn,* No. 1800, Apr., 1846—K, NSW).

Other Collections:

Tasmania—Knocklofty, Hobart (? *L. Rodway,* June, 1895—HO); without locality (*W. V. Fitzgerald,* 1891—MEL); Strzelecki Peak, Flinders Island (*J. H. Willis,* Apr. 1954—MEL).

Victoria—? Dimboola (*E. Muir,* 1948—MEL); Bahgallah, near Casterton (*R. C. Miller*, June, 1885—MEL); Portland (*J. A. Leach, June,* 1906—MEL); Macedon (MELU); Apollo Bay (MELU); Port Phillip (*C. French, June,* 1869—MEL); Studley Park (*W. Kershaw,* 1857—Herb. R. C. Kershaw; *F.M. Reader,* June, 1885—Herb. Vict. Dept. Agric., Burnley); "Comellia" (*C. French,* May, 1900—Herb. Vict. Dept. Agric., Burnley); Kew (MELU); Doncaster (*P. Fisch,* June, 1942—MEL, MELU); Dandenong (*F. Gessner,* 1892—MEL); Kallista (*E. I. McLennan,* Aug., 1949—MELU); Dandenong Ranges (MEL); Kalorama (Mrs. *Peters,* May, 1957—MELM); Mornington (MELU); Tyabb (Master *Blackwood*, Nov., 1920—MELM); Nyora (MELU); Korumburra (MELU); Orbost (MELU); Mallacoóta (*W. Hunter*, Oct., 1955—MEL); Wangaratta (*M. Ferris,* June, 1956—ADW No. 7450); Tarra Valley Nat. Park (Mrs. *K. Healey*, June, 1959—MEL).

[Noted also as abundant at Emerald and Cockatoo.]

South Australia—Penola (*C. Barrett,* June, 1931—MELU); Sellick's Hill (Dr. *E. C. Stirling*—ADM); Kingston (Dr. *A. Engelhardt*—ADM; *J. B. Cleland*, Aug., 1943—MEL; June, 1943—ADW Nos. 266–268; *J. B. Cleland,* July, 1942—ADW No. 3143; *A. R. Naimes,* Aug., 1945—ADW No. 3145).

New South Wales—Shoalhaven River (? W. Bäuerlen, June, 1888—MEL); Kurrajong Heights (SYDM); Bola Creek, National Park (*J. McLuckie, A. Burges & N. White,* June, 1932—SYD); Whitton, Murrumbidgee River (*A. J. Foster,* June, 1921—NSW No. 3486/21); near Albury (*A. G. Hamilton*, June, 1917—NSW).

[Noted also in the Blue Mountains and on Hunter River.]

Queensland—Rain forest in Lamington National Park (*A. B. & J. W. Cribb*, May, 1955—Herb. A. B. Cribb, Brisbane).

The common big-fruited *C. gunnii* is very closely related to, and has been much confused with, *C. hawkesii*—or what the writer interprets as that species. In the latter fungus the capitulum is brownish (*not* dark green); remaining quite smooth and unaltered when dry. Furthermore, there is a *sharp line of demarcation* between the apex of stipe and fertile (perithecia-bearing) part of the sporophore; in *C. gunnii,* by contrast, the dark green (at length black and wrinkled) fertile portion grades insensibly into a yellow stipe and the perithecial mouths protrude slightly when specimens are dried. Joan Dingley (1953, p. 335) has reduced the names of Lloyd's two New Zealand species *C. craigii* and *C. hillii* (*l.c.*) to synonyms of *C. gunnii,* apparently without inspection of their types; but the original figures of both show rather well delimited capitula and might equally pass for *C. hawkesii,* hence the present writer's query prefixing the synonymy of these under *C. gunnii.* Miss Dingley kindly made available for examination two excellent specimens of *Cordyceps* from New Zealand, collected about 1920 by H. Hamilton on the larvae of *Oxycanus enysii* at Wireless Hill, near Wellington. These had been determined by Dr. G. H. Cunningham at *C. craigii* Lloyd; but they are certainly referable to a small form of *C. gunnii,* with which Dingley also identified this collection (1953, p. 335). Probably both *C. gunnii* and *C. hawkesii* occur in New Zealand.

C. hawkesii (G. R. Gray) Cooke in *Grevillea* **19**: 76 (1891).

(Plate IX, figs. 4–6).

Sphæria hawkesii G. R. Gray *Notices Insects . . . Fungoid Parasites* 8, t. 5 fig. 10–12 (1858).

? *Cordyceps pieli* Olliff in *Agric. Gaz. N.S.W. 6*: 412, t. 2 fig. A (1895)—TYPE (N.S.W.) on caterpillar of *Trictena labyrinthica* Don at Coonamble, N.S.W. (*J. H. Rose*, c. 1894).

Host: Oxycanus & Trictena spp. (*Lepidoptera*—Hepialidæ).

Type: Near Launceston, Tas. (Mr. *Hawkes,* ca.1846—? BM).

Other Collections: Mussel Roe, N.E. Tas. (? *L. Rodway*—HO); Track to Marriott's Falls, Mt. Field National Park, Tas. (*O. Rodway,* Sept. 1924—HO); Koonung Creek, Doncaster, Vic. (Mr. & Mrs. *Paul Fisch,* June, 1942—MEL, ADW No. 3144); Perrin's Creek, Olinda, Vic. (*Ina Watson,* July, 1942—MEL); Mt. Evelyn Recreation Reserve along Olinda Creek, Vic. (*A. B. Court,* July, 1958—MEL); Tarra Valley Nat. Park, Vic. (Mrs. *K. Healey,* June, 1959—MEL); Snowy River near Orbost, Vic. (*J. Cameron,* 1890—MEL, as "*C. cameroni*" ms.); without locality, Vic. (MELM); Coonamble, N.S.W. (TYPE *C. pieli, l.c.*); Rain forest in Lamington National Park, Q'land (*A. B. & J. W. Cribb*, May, 1954—Herb. A. B. Cribb, Brisbane).

Until the actual type of *C. hawkesii* can be located and studied, its circumscription must depend upon G. R. Gray's three drawings and rather hazy account (*l.c.*). Gray was Senior Assistant at the Zoology Department, British Museum, and he stated unequivocally "Various examples . . . are among the specimens sent by Mr. Hawkes to the British Museum"; yet C. G. Lloyd (Mar., 1915, p. 6) avers "I found no specimen of *Cordyceps hawkesii* in either of the museums at London"—one wonders whether his search extended to the Zoological Department as well as the Botanical? No other writer seems ever to have examined the original material of this parasite. The following points of departure from *C. gunnii* are emphasized by Gray: stipe irregular, flexuose, much *more slender* (in some examples no thicker than a straw), *fulvous-woolly* on the buried portion (especially toward soil surface), springing from "various portions of the body of the caterpillar", the terminal club not nearly so thick or dark as in *C. gunnii*. None of these features *per se* (except the woolly investment) is of much significance in a highly polymorphic fruiting body like that of *C. gunnii*, but Gray's figures do portray a fungus with sharply determinate fertile apices.

The name *C. hawkesii* is here applied, not without some misgiving, to a population having bay- to coffee-brown, often dilated or contorted, sharply defined fertile clubs that are always wider than their stipes; this fungus may grow in company with, but remains distinct from, *C. gunnii*. The writer believes it to be conspecific with Olliff's *C. pieli* (*l.c.*)—a name which might have to be taken up, if the type of *C. hawkesii* can ever be found and referred to some other taxon. Perithecial mouths are comparatively much broader than in *C. gunnii*, almost touch each other and do *not* protrude, while the filiform sporidia do not readily break up into secondary spores, each of which is $\pm 2{\cdot}5$ mic. long (sporidia of *C. gunnii* soon separate into rectangular secondary spores 3–5 $\times$ 2·5 mic.—*cf.* 2·5–3 $\times$ 2 mic. given by Dingley, 1953). Both species have glabrous or, at most, only microscopically felted stipes—without a sign of the woolliness ascribed to *C. hawkesii* by its author. *C. cranstounii* and *C. robertsii* are more or less woolly about the lower parts of the stroma, in Victoria inhabiting the same host as *C. hawkesii*, but they differ from it in many other respects.

C. meneristitis F. Muell. & Berk. in *Gdnrs' Chron.* ser. 2, **10**: 791, fig. 130 (1878)—ut "*C. menesteridis*" in err.

C. entomorrhiza (Fr.) Link var. "*menesteridis*" (F. Muell. & Berk.) Cooke *Handb. Aust. Fungi* 277 (1892);

C. gracilis sens. Lloyd *Synops. Cordyceps Australasia* 10 (1915), *non certe* Durieu & Montagne (1846);

? *C. gracilioides* Y. Kobayasi in *Sci. Rep. Tokyo Bunrika Daig.* (B) *84*: 140–42 (1941)—TYPE (Herb. Kobayasi) on coleopterous larvæ at Mt. Takao-san, Musasi Prov., Japan (*Y. Kobayasi*, July, 1936).

Descriptio amplificata:

Stipes 2–5 cm. longus, 1–3 mm. crassus, paulum curvatus vel flexuosus, tenue farinaceo-squamulosus, superne pallidi-carneus, subter ochraceus. *Caput* fertile terminale, ellipsoideum, 5–10 $\times$ 3–5 mm., nitidulum, castaneo-fulvum (interne ochraceum), interdum geminatum. *Perithecia* omnino immersa, ad partem latissimam 0·6–0·8 $\times$ 0·16–0·23 mm. *Ostiola* minuta, atra, 60–80 mic. diam., 200–320 mic. disjuncta, ad apicem densiora. *Asci* longe cylindrici 200–450 $\times$ 3–4 mic., capitibus subglobosis 3–4 mic. altis. *Articuli ascosporarum* 6–7 $\times$ 1–1·5 mic., quisque 3–septatus apparens. Status conidialis ignotus.

Host: Meneristes laticollis Boisd. & *Lepispilus* spp. (*Coleoptera*—Tenebrionidæ).

Type: Mouth of Yarra River, Vic. (*C. French,* c. 1878—K, MEL).

Other Collections: Near Melbourne, Vic. (Miss *J. Raff,* June, 1908—MEL); Creswick, Vic. (*J. H. Willis,* Aug., 1929—MEL); Kalorama, Vic. (*J. H. Willis,* May, 1946—MEL); Boronia, Vic. (*F. R. Fleet,* Oct., 1953—MELM); Carrum, Vic. (*C. Oke,* Sept., 1930—MELU); "Southern Tablelands," N.S.W. (*J.W.W.,* 1921—SYD); Mt. Nelson Range, ? near Hobart, Tas. (? *L. Rodway,* July, 1919—HO).

According to the joint authors (*l.c.*), type was found "on the caterpillar of *Menesteris laticollis* Boisd."—an obvious mistake for *Meneristes laticollis,* there being no insect genus "*Menesteris*". Thus it is permissible to correct the genitive spelling of the epithet, from "*menesteridis*" to *meneristitis.* Moreover, the host is a tenebrionid beetle larva, not a "caterpillar".

Cooke (*l.c.*) reduced *C. meneristitis* to a variety of the European *C. entomorrhiza;* but the latter has a filiform, toughly rigid stipe (*not* fleshy as in *meneristitis*), with blackish globoid capitulum (violet-coloured internally) and these two taxa are not closely allied at all. *C. meneristitis* has much more in common with *C. gracilis*—first described from Algeria, but ranging through Europe, China, the United States and Brazil—and C. G. Lloyd (Mar., 1915, pp. 10–11) merged it with this widespread species. *C. gracilis,* however, is a parasite on lepidopterous larvæ and the stipe is characteristically clothed near the base with *branched mycelial rhizoids* or fibres. Kobayasi (1941, p. 143) tabulates the differences between the related species *C. glaziowii* Henn. (from Brazil), *C. gracilis* Durieu & Montagne and *C. gracilioides* Kobayasi (*l.c.*, p. 140); under the last novelty, from Japan, he places as a doubtful synonym *C. meneristitis* ("*menesteridis*"), with the remark "sp. imperfecte cognita". But *C. meneristitis* is now no less well known in Victoria than most other species of *Cordyceps,* and there do not seem to be adequate grounds for recognizing *C. gracilioides* as distinct. Except in the longer wider asci (600–700 × 6–6·5 mic.), Kobayasi's description fits the Victorian plant admirably, so his name is listed above as a synonym of *C. meneristitis*—with prefixing query, because the present writer has had no opportunity to compare actual types.

Should some future worker decide that *C. meneristitis* (despite its different host and consistently bare stipe) is not sufficiently distinct from *C. gracilis* to justify specific rank, then the latter, older name must prevail. Incidentally, Kobayasi's identification of the host in *C. gracilioides* (*l.c.*, p. 141) as "Larvæ of *Cossidæ* (Coleoptera)" is absurd, *Cossidæ* being a family of large wood moths (*Lepidoptera*) and having nothing to do with the *Coleoptera* (beetles).

C. militaris (Fr.) Link *Handb. Erkenn. . . . Gewächse* **3**: 347 (1833).

Sphaeria militaris Fr. *Syst. Mycol. 2*: 323 (1823).

Host: Various genera of *Lepidoptera,* sometimes *Coleoptera* and even *Hymenoptera.*

Type: Apparently none.

Australian Collections: Apollo Bay, Vic. (*F. J. Halsey,* Sept., 1935—MELU; Miss *M. Fawcett,* Sept., 1937—MELU); Turton's Track, near Beech Forest, Vic. (May 1936—MELU).

Dr. Ethel I. McLennan, of the Botany School, Melbourne University, determined the three collections cited above (from Otway Ranges) as *C. militaris*—a variable fungus widespread through Europe, Asia and North America. Although these Victorian representatives have smaller-than-average stromata, they were correctly identified (in the writer's opinion). No other Australasian occurrence of *C. militaris* has been reported, but this orange-headed species is most likely to exist in other fern-gully habitats of south-eastern Australia (including Tasmania).

C. robertsii (Hook.) Berk. in Hook. f. *Flor. N.-Z.* **2**: 202 (1855). (Plate VII).

Sphaeria robertsii Hook. *Icon. Plant. 1*: t. 11 (1836);

S. huegelii Corda *Icon. Fungorum 4*: 44, t. 9 fig. 129 (1840)—TYPE (? PR) from New Zealand (Baron *C. v. Hügel,* 1834);

S. forbesii Berk. in *Lond. J. Bot. 7*: 578 (1848)—nomen nudum;

Clavaria larvarum Westwood in *Proc. ent. Soc. Lond. 2*: 6 (1836)—nomen nudum;

Cordyceps huegelii (Corda) Corda *Anleit. Stud. Mycol.* 207, t. F fig. 22 (1842);

C. larvarum Olliff in *Agric. Gaz. N.S.W. 6*: 410 (1895)—nomen superfl.;

C. selkirkii Olliff *l.c.* 411, t. 4 fig. B (1895)—TYPE (? SYDM, ? HO) "on caterpillars of *Pielus hyalinatus* Herr. Sch. and *Pielus* sp." at Kurrajong Heights, N.S.W. (*H. Selkirk,* early 1894).

Host: Oxycanus spp. and perhaps related genera (*Lepidoptera*—Hepialidæ).

Type: New Zealand, without precise locality (Mr. *Roberts*—? K).

Australian Collections:

New South Wales—Kurrajong Heights (? *H. Selkirk*—SYDM, HO, as *C. selkirkii* Olliff); "Hotel Australia", Eden (*Gabon,* Mar., 1908—NSW No. 927/08, barren and dubious specimen); Road between Fitzroy Falls and Nowra (*E. Cheel & J. B. Cleland,* June, 1919—NSW); National Park (*J. McLuckie & A. Burges,* June, 1932—SYD); Bola Creek, National Park (*A. Burges,* Mar., 1947—SYD); National Park (*C. M. Eardley & A. Burges,* Apr., 1947—ADW No. 269).

Queensland—Rain forest in Lamington National Park (*A. B. & J. W. Cribb,* May, 1955—Herb. A. B. Cribb, Brisbane, also MEL).

Victoria—Tyrendarra, near Portland ("Pres. Trng. College Educ. Dept.", June, 1912—MELM); Koroit (*R. T. M. Pescott,* Aug., 1932—MELU, barren specimen); Koonung Creek, Doncaster (Mr. & Mrs. *Paul Fisch,* June, 1942—MEL, MELU, ADW No. 3146); Rye (Mrs. *Paul Fisch,* Sept., 1956—MEL); Tarra Valley Nat. Park (Mrs. *K. Healey,* June, 1959—MEL).

Tasmania—? *loc.* (Dr. *Crivelli*—MEL); "Southern Tasmania" (? *L. Rodway,* Nov. 1914—HO); Mt. Wellington, 200 ft.

(? *L. Rodway,* Aug. 1924—HO); Cascades, Hobart (? *L. Rodway,* May, 1924—HO); Track to Lady Barron Falls, Mt. Field National Park (? *L. Rodway,* June, 1924—HO).

[Noted also at Willoughby (Sydney) and Rope's Creek in New South Wales; at Warrandyte, Wonga Park and Kalorama (Dandenong Ranges) in Victoria.]

Charles Robin (1853, pp. 655–660) devoted six pages to his description of *C. robertsii,* in French, giving a remarkably detailed account of its anatomy and furnishing a coloured illustration. The synonymy set out by Joan Dingley (1953, p. 331) is unfortunately marred by at least five errors in the quotation of literary references. As pointed out by her (*l.c.,* p. 332), Kobayasi erred in taking up the name *C. larvarum* (Westwood) Olliff, because its basionym *Clavaria larvarum* Westwood (1836) was a *nomen nudum*; but *Sphæria robertsii* Hook. (1837) was validly published, with short description and unmistakable drawing, so the legitimate name must be *C. robertsii* (Hook.) Berk. in Hook. f.

The writer agrees with Kobayasi (1941, p. 99) and Dingley (*l.c.*) in reducing *C. huegelii* (Corda) Corda and *C. selkirkii* Olliff to synonymy under *C. robertsii.* Undivided stromata are the usual attribute of this species in New Zealand, but Australian populations are very frequently branched (the "*C. selkirkii*" form), and even the precise line of demarcation between *C. robertsii* and the usually much larger *C. taylori* sometimes appears hazy. Dingley (1953, p. 331) describes the perithecia of New Zealand collections as 0·4–0·5 mm. wide, whereas both Cunningham (1921, p. 378) and Kobayasi (1941, p. 102) give a measurement of 0·3–0·4 mm. The only two New Zealand specimens of *C. robertsii* in Melbourne Herbarium show the mature perithecia to be even narrower (0·15–0·2 mm.), just as in Australian examples; so the size of these receptacles would seem to be rather variable.

C. scottiana Berk, ex Olliff in *Agric. Gaz. N.S.W.* **6**: 407, t. 1 (1895).
? *C. heteropoda* Y. Kobayasi in *Sci. Rep. Tokyo Bunrika Daig.* (B) *84*: 144–47 (1941)—TYPE (Herb. Kobayasi) on *Tibicen bihamatus* Motschulsky at Toyohira-kyo, Isikari Prov., Japan (*Y. Kobayasi,* Aug., 1937).

Host: Rhyssonotus nebulosus Kirby (*Coleoptera*—Lucanidæ), apparently also cicada larvæ (*Cicadidæ*).

Type: Ash Island, Hunter River, N.S.W. (*A. W. Scott,* Sept., 1861—? *loc.*). ICONOTYPE (by Mrs. Helena Forde) reproduced with original diagnosis (*l.c.*).

Known only with certainty by the type (if still in existence), description and original coloured figure (*l.c.*), *C. scottiana* must be very close indeed to the true, boreal *C. gracilis* Durieu & Montagne; but it has much longer, yellowish-red mycelial strands at the base of stipe and inhabits a coleopterous (or hemipterous) *not* lepidopterous host. Lloyd (1920, p. 911) acclaimed it as "the only one of Mr. Olliff's species that appears good to us". Berkeley received specimens of what he proposed to call "*Sphæria scottiana*" from Mr. Scott (the collector), but does not appear to have published any description of them; it is possible for this material to be among his other very numerous fungal specimens at Kew. In the Insect

Gallery of The Australian Museum at Sydney is a specimen labelled "*Cordyceps scottianus* Olliff. Cooma, N.S.W. Melolonthid grubs". But it has not been possible to ascertain whether this collection is really conspecific with the original Hunter River material or, which is more likely, represents some other *Cordyceps* (perhaps *C. meneristitis*—already known from the Southern Tablelands). Pending a search for fresh material in the type area, the benefit of the doubt is accorded this taxon, and it is admitted here as a "good" species with one possible (if unproven) synonym.

Kobayasi (1941, p. 144) established a new species, *C. heteropoda,* for Japanese material hitherto referred by Kawamura (1929) to the Australian *C. scottiana,* and he took pains to tabulate (p. 147) the differences between the two. Because Kobayasi had to rely on the inadequate description of *C. scottiana* his conclusions are questionable. A curious misinterpretation of terms is obvious in his comparison of the palisade cells (which form a periphery to each fertile capitulum). The words "coated with a layer or envelope of oblong cells", in the case of *C. scottiana,* were taken "*en bloc*" from Olliff's diagnosis; however, by "cells" the latter author was referring to perithecia and certainly *not* to the hyphal matrix in which these receptacles are embedded! The only significant difference between *C. scottiana* and *C. heteropoda* is the larval host—stag bettle in the former, cicada in the latter population—and that, *per se,* does not constitute a reliable basis for speciation.

C. taylori (Berk.) Sacc. *Michelia* **1**: 320 (1878).

Sphaeria taylori Berk. in *Lond. J. Bot. 2*: 209, t. 8 fig. 2 (1843);
S. innominata R. Taylor in *Tasm. J. nat. Sci. Agric. Statist. 1*: 307–8, illust. (1842);
Cordyceps trictenæ Olliff in *Agric. Gaz. N.S.W. 6*: 410, t. 3 (1895);
C. henleyæ Massee in *Ann. Bot., Lond. 9*: 28, t. 1 fig. 1–12 (1895)—TYPE (K, MEL) on *Trictena* sp., Ovens River, Vic. (Miss *M. Henley*, 1893);
C. melbourniensis Lloyd *Mycol. Notes* 7^{75}: 1353, fig. 3153 (1925)—nomen provis.

Host: Trictena spp. (*Lepidoptera*—Hepialidæ).

Type: *Murrumbidgee River, 10 miles from *Yass, N.S.W. (*J. Allan,* Mar., 1837—K).

Other Collections:

New South Wales—Queanbeyan (*H. Selkirk,* 1896—NSW No. 6895).

Victoria—Gerangamete, Otway Ranges (*J. Davis,* Nov., 1886 MELM; *Carr,* 1886—MEL; *J. Price,* July, 1886—MEL; *H. Ireland,* June, 1891—MEL); Apollo Bay (*Mott,* 1892—MEL; *J. E. Syme,* 1906—NSW No. 4095); Beech Forest (*J. M. Reed,* June, 1918—MELM; *C. C. Brittlebank,* 1926—SYD, as "*C. melbourniensis*"); Forrest (Sawmill Employees' Assocn., Sept., 1912—MELM); Cape Otway Ranges (1894—MEL); Cape Otway (SYDM Nos. A48, K100, K349); ? Caulfield (*W. Kershaw,* 1870—MELM); South Gippsland (per Editor "*Australasian*", June, 1892—MELM); Strzelecki Ranges (*W. Johnstone,* July, 1895—MEL); Snowy Creek, between Omeo and Tallangatta

* Spelt "Murrambidgee" and "Yap" in the original diagnosis.

(Mrs. *McCann,* 1889—MEL); Ovens River (Miss *M. Henley,* 1893—MEL, duplicate type *C. henleyæ* Massee); Harrietville (*J. Gardner,* June, 1933—MELU).

Without doubt, the first validly published description of this taxon was under the name *Sphæria innominata,* by Rev. Robert Taylor (1842). His material came from the same suite of specimens (Murrumbidgee River, 1837) which furnished Berkeley with the type of *S. taylori*—published the following year, apparently in ignorance that Taylor himself had already described this fungus in an obscure colonial journal. There would seem to be a clear case for making the new combination, *Cordyceps innominata*; yet, one hesitates to do so in deference to Article 77 of the International Code of Botanical Nomenclature (Stockholm, 1950), which demands the rejection of any name or epithet " when it is based on a monstrosity ". Now Taylor's figure of *Sphæria innominata* portrays a stroma with numerous, tightly aggregated (cauliflower-like) and apparently sterile branches—quite atypical of the fructification (spreading, antler-like and sparingly branched) that one is accustomed to associate with the name *C. taylori.* Was the type specimen of *S. innominata* a " monstrosity "? The present writer believes it was, and, if so, we can conveniently reject this name.

But, *is* the type (preserved at Kew) of Berkeley's *S. taylori* any more normal? Among fungi, which are notoriously polymorphic, *who* is to decide whether any particular specimen satisfies the concept of a monstrosity or not?* The type figure of *S. taylori* also shows a densely branched, cauliflower-like stroma (without perithecia) and might well come under the category of a " monstrosity "—in which case Massee's later name *C. henleyæ* (*l.c.*) would be applicable; but even *C. henleyæ* does not typify the usual fructification of this parasite, being etiolated with long narrow branches. Lloyd (Mar., 1915, p. 8) remarked:

> I am not satisfied that *C. taylori* is the same plant as our photograph. The type is preserved at Kew and it has 15–20 immature branches, resembling the head of a Medusa. There are several collections (as our figure) received at a later date, at Kew and the British Museum, and referred to this species. Not one of them had more than four primary branches, and are quite different in appearance to me from the original specimen.

Both of the forms mentioned by Lloyd have been found growing on the same large moth larva (*Trictena* sp.—probably *T. argentata*) in the Otway Ranges, Vic., where sporophores vary from simple or once-forked to intricately and much-branched structures. The present writer does not doubt that these represent one and the same species.

An interesting speculation arises: could all the populations of "*C. taylori*" be interpreted as merely a vigorous and obese development of *C. robertsii,* adapted to growth on a much larger host (*Trictena* instead of the usual *Oxycanus*)? The actual perithecial differences between these two entities are very slight, and the criteria for separating them seem rather artificial—viz., size, shape and degree of branching. E. Cheel, as reported by Lloyd (1920, p. 911), made the suggestion that *C. henleyæ* was merely a branched condition of *C. robertsii*; but, from its robustness and choice of host (*Trictena*), the writer would certainly identify it with *C. taylori.* The fact that in Victoria one may find branched specimens of undoubted *C.*

* Regarding monstrous forms, see apposite remarks by C.G.G.J. van Steenis in *Flora Malesiana* 5³: clxxi (May 1957).

robertsii on *Oxycanus* and unbranched examples of C. *taylori* on *Trictena*—perithecia being variable in both—indicates a strong affinity between the two. Yet, to sweep *all* the forms of robust *C. taylori* into the synonymy of slender *C. robertsii* would presuppose far more knowledge of these intriguing fungi (and their life-histories) than we possess. For the present, the writer prefers to retain the familiar name *C. taylori* (even if strictly illegitimate) and apply it to those massive, usually branched growths on *Trictena* in mountain country, leaving the solution of a major taxo-nomenclatural dilemma to abler investigators of the future.

As pointed out by Rodway (1920, p. 116), Olliff's *C. trictenæ* (*l.c.*) is simply an inadvertent re-description of type *C. taylori,* based upon the selfsame illustration that accompanied Berkeley's original account of *Sphæria taylori* (1843). Lloyd's name "*C. melbourniensis*" (1925, p. 1353) is provisional and has no standing; it was suggested, as a comment, with the recording of a curious form of *C. taylori* collected by C. C. Brittlebank (presumably near Melbourne, but most probably from Beech Forest in the Otway Ranges).

C. sp. [aff. *C. entomorrhiza* (Dickson) Fr.].

Host: Othnonius batesii (*Coleoptera*—Scarabæidæ).

Locality: Graman, N.S.W. (*T. V. Bourke,* 1958, also May–June, 1959—MEL).

The single collection consists of a number of mummified cockchafer larvæ, each with several fructifications (1-4 cm. long) from various parts of the body integuments; two stipes carry mature spore-bearing capitula. In aspect, gross morphology, colouration, ascal and spore details, the material can hardly be distinguished from *C. aphodii* J. Mathieson; yet the more compact perithecia are definitely arranged *at right-angles* to the capitular axis, not obliquely as in that Victorian species. By this feature it approaches the European *C. entomorrhiza*—a much larger plant with blackish subglobose capitula about 6 mm. wide. One is tempted to query the reliability of perithecial orientation, as a primary feature in classifying *Cordyceps,* and to wonder whether *C. aphodii* and the undetermined fungus from Graman (N.S.W.) may not, in fact, be forms of the same species.

LITERATURE RELATING TO AUSTRALIAN SPECIES OF *CORDYCEPS.*

Berkeley, M. J., 1843. On some entomogenous Sphaeriæ. *Lond. J. Bot. 2*: 205–211, t. 8.
———, 1848. Decades of fungi. *Lond. J. Bot. 7*: 577–78, t. 22.
———, 1855. Nat. Ord. CII Fungi. *Flora Novæ Zelandiæ 2*: 202.
———, 1856. Decades of fungi. *Hook. J. Bot. Kew Gdn. Misc. 8*: 278.
Coleman, Edith, 1945. Autumn fungi at Emerald. *Vict. Nat. 62*: 4–5 (illust.).
Colenso, W., 1842. Botanical information (extract from N.Z. letter). *Lond. J. Bot. 1*: 304–05.
Cooke, M. C., 1891 (Mar.). Australian Fungi. *Grevillea 19*: 76.
Cooke, M. C., 1892 (Aug.). *Handbook of Australian Fungi* 277, t. 22 fig. 184.
———, 1892. *Vegetable Wasps and Plant Worms* 1–218, figs. 30, 31, 34, 35, 39, t. 1 fig. 8.
Cooke, M. C., & Massee, G., 1889. New Australian fungi. *Grevillea 18*: 8, 45.
Corda, A. C. I., 1840. *Icones Fungorum 4*: 44, t. 9 fig. 129.
Cunningham, G. H., 1921. The genus *Cordyceps* in New Zealand. *Trans. N.Z. Inst. 53*: 372–82, t. 59–62.
Currey, *F.*, 1858. Synopsis of the fructification of the Compound *Sphaeriæ* of the Hookerian Herbarium. *Trans. Linn. Soc. Lond. 22*: 262–265, t. 45.

DINGLEY, JOAN M., 1953. The Hypocreales of New Zealand (V. The genera *Cordyceps* and *Torrubiella*). *Trans. roy. Soc. N.Z. 81*: 329–339.

GRAY, G. R., 1858. *Notices of Insects that are known to form the bases of Fungoid Parasites*, pp. 22, tt. 5.

HARRIS, J. R., 1946. The "Vegetable Caterpillar" Cordyceps Gunnii. *S. Aust. Nat. 23*[4]: 2–6, t. col. (cover).

HOOKER, W. J., 1836. *Icones Plantarum 1*: t. 11.

KOBAYASI, Y., 1941. The genus *Cordyceps* and its allies. *Sci. Rep. Tokyo Bunrika Daig.* (B) *84*: 53–216 (illust.).

LINK, H. F., 1833. *Handbuch zur Erkennung der nutzbarsten und am häufigsten vorkommenden Gewächse 3*: 347.

LLOYD, C. G., 1915 (Mar.). *Synopsis of the Cordyceps of Australasia* 1–12, fig. 611–626.

————, 1915 (Dec.). Additional notes on Cordyceps. *Mycol. Notes 4*[39]: 527–28.

————, 1920. Additional notes on Cordyceps. *Mycol. Notes 6*[62]: 911–12, fig. 1618, 932 fig. 1695.

————, 1925. *Mycol. Notes 7*[75]: 1353, fig. 3153.

MCALPINE, D., 1895. *Systematic Arrangement of Australian Fungi* 110.

————, 1895 (Sept.). *Isaria surmatodes* McAlp. (n. sp.). *Vict. Nat. 12*: 64.

MCALPINE, D., & HILL, W. H. F., 1895. The entomogenous fungi of Victoria. *Proc. roy. Soc. Vict.* n. ser. *7*: 159–165.

MCLENNAN, ETHEL, & COOKSON, ISABEL, 1923. Additions to the Australian Ascomycetes. No. 1. *Proc. roy. Soc. Vict.* n. ser. *35*: 157, t. 10.

————, 1926. Additions to Australian Ascomycetes. No. 2. *Proc. roy. Soc. Vict.* n. ser. *38*: 74–75, t. 5 fig. 5–6, t. 6 fig. 4–5.

MASSEE, G., 1894. A new Cordyceps. *Ann. Bot., Lond. 8*: 119.

————, 1895. *Cordyceps henleyæ*, sp. nov. *Ann. Bot., Lond. 9*: 28, t. 1 fig. 1–12.

MATHIESON, JEAN, 1949. *Cordyceps aphodii*, a new species, on pasture cockchafer grubs. *Trans. Brit. mycol. Soc. 32*: 113–136, t. 12–14.

MUELLER, F., & BERKELEY, M. J. Cordyceps menesteridis. *Gdnrs' Chron.* ser. 2, *10*: 791, fig. 130 (1878).

OKE, C., 1923. Exhibits (from Natya excursion). *Vict. Nat. 40*: 104.

OLLIFF, A. S., 1895. Australian entomophytes, or entomogenous fungi, and some account of their insect-hosts. *Agric. Gaz. N.S.W. 6*: 402–414, t. 1–4.

PETCH, T., 1933. Notes on entomogenous fungi. *Trans. Brit. mycol. Soc. 18*: 50–51, 57, 66–67.

————, 1936. *Cordyceps militaris* and *Isaria farinosa*. *Trans. Brit. mycol. Soc. 20*: 216–24.

ROBIN, C., 1853. *Histoire Naturelle des Végétaux Parasites* 647–660, *Atlas* t. 8 fig. 6.

RODWAY, L., 1900. On a new Cordiceps. *Pap. roy. Soc. Tasm. 1898–1899*: 100–02 (illust.).

————, 1920. Notes and additions to the fungus flora of Tasmania. *Pap. roy. Soc. Tasm. 1919*: 116.

SACCARDO, P. A., 1878. Enumeratio Pyrenomycetum Hypocreacearum hucusque cognitorum systemate carpologico dispositorum. *Michelia 1*: 320.

SACCARDO, P. A., 1883. *Sylloge Fungorum 2*: 567–575.

SKUSE, F. A. A., 1891. The New Zealand Vegetable Caterpillar. *Vict. Nat. 8*: 47–8.

STEEL, T., 1890. The New Zealand Vegetable Caterpillar. *Vict. Nat. 7*: 110–114.

TAYLOR, R., 1842. The Bulrush Caterpillar. *Tasm. J. nat. Sci. Agric. Statist.* 1[4]: 307–08 (illust.).

TEPPER, J. G. O., & MCALPINE, D., 1897. Some South Australian forms of *Cordyceps Gunnii* Berk. *Agric. Gaz. N.S.W. 8*: 138–140 (illust.).

TISDALL, H. T., 1889. A curious fungus. *Vict. Nat. 6*: 119.

————, 1893. On a species of Isaria. *Vict. Nat. 10*: 90–96.

TRYON, H., 1893. Insects as fungus hosts. *Trans. nat. Hist. Soc. Qd. 1*: 53–55.

WESTWOOD, J. O., 1891. Parasites on plants and animals. *Gdnrs' Chron.* ser. 3, *9*: 553, 557 fig. 111.

WILLIS, J. H., 1934. "Vegetable Caterpillars." *Vict. Nat. 50*: 302–04, fig. 1.

————, 1957. *Victorian Toadstools and Mushrooms* ed. 2: 83–86, t. 16, fig. 17.

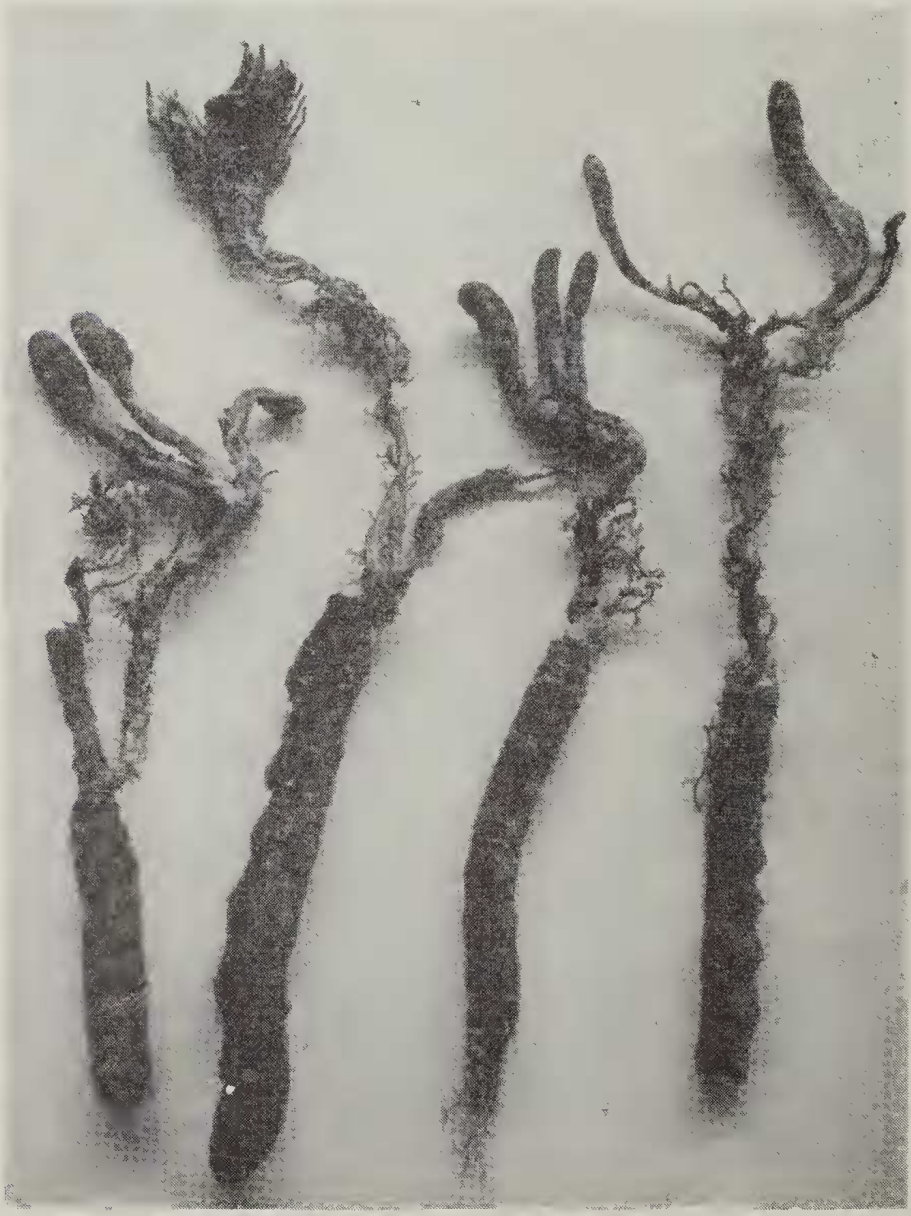
PLATE VII

Cordyceps robertsii (Hook.) Berk.

(Specimens from Koonung Creek, Doncaster, Vic., on larvæ of *Oxycanus diremptus*, June, 1942)

—*Photo.* by courtesy H. T. REEVES.

PLATE VIII



Cordyceps cranstounii Olliff.

(Specimens from Koonung Creek, Doncaster, Vic., on larvæ of *Oxycanus diremptus*, June, 1942)

—*Photo.* by courtesy H. T. REEVES.

PLATE IX

Cordyceps gunnii (Berk.) Berk.—figs. 1–3;
? *C. hawkesii* (G. R. Gray) Cooke—figs. 4–6..

(Specimens from Koonung Creek, Doncaster, Vic., on larvæ of *Oxycanus diremptus*, June, 1942)

—*Photo.* by courtesy H. T. REEVES.